Assessment Variables in Appalachian Headwater and Perennial Streams

United States Army Corps of Engineers, ERDC

US Army Corps of Engineers
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Assessment Variables – Headwater Streams

- Channel Canopy Cover
- Channel Substrate Embeddedness
- Channel Substrate Size
- Channel Bank Erosion
- Large Woody Debris
- Riparian/Buffer Zone Tree Diameter
- Riparian/Buffer Zone Snag Density
- Riparian/Buffer Zone Sapling/Shrub Density
- Riparian/Buffer Zone Vegetation Species Richness
- Riparian/Buffer Zone Soil Detritus
- Riparian/Buffer Zone Herbaceous Cover
- Watershed Land-use

Assessment Variables – Headwater Sampling Locations

Watershed Variables

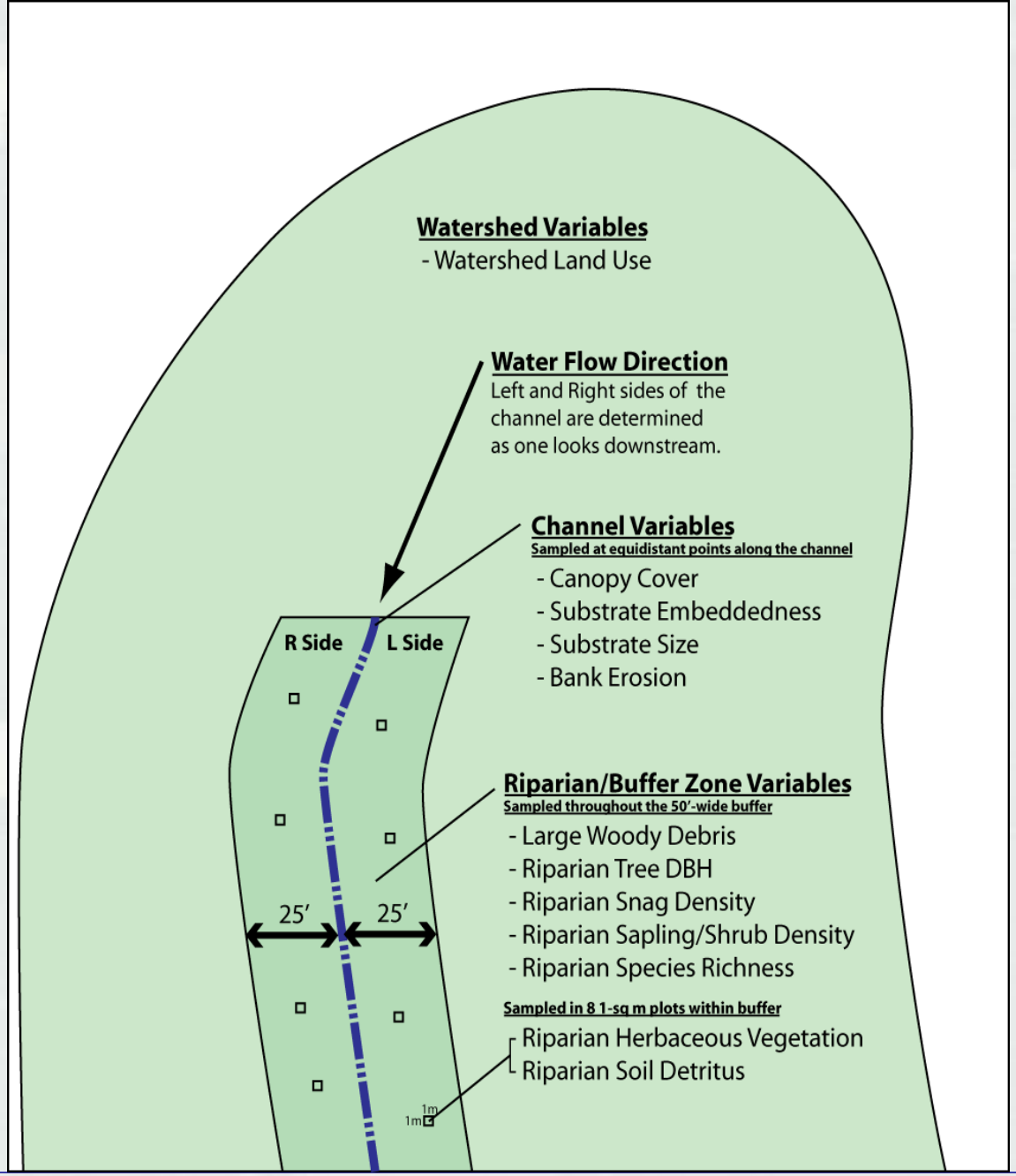
- Watershed Land-use

Channel Variables

- Canopy Cover
- Substrate Embeddedness
- Substrate
- Bank Erosion

Riparian/Buffer Zone Variables

- Large Woody Debris
- Riparian Tree DBH
- Riparian Snag Density
- Riparian Sapling/Shrub Density
- Riparian Species Richness
- Riparian Herbaceous Vegetation
- Riparian Soil Detritus


Watershed Variables
- Watershed Land Use
Water Flow Direction
Left and Right sides of the channel are determined as one looks downstream.
Channel Variables
Sampled at equidistant points along the channel
- Canopy Cover
- Substrate Embeddedness
- Substrate Size
- Bank Erosion
R Side
L Side
Riparian/Buffer Zone Variables
Sampled throughout the 50'-wide buffer
- Large Woody Debris
- Riparian Tree DBH
- Riparian Snag Density
- Riparian Sapling/Shrub Density
- Riparian Species Richness
25'
25'
Sampled in 8 1-sq m plots within buffer
Riparian Herbaceous Vegetation
Riparian Soil Detritus
1m
1m

Channel Canopy Cover – Headwater Streams

($V_{CCANOPY}$)

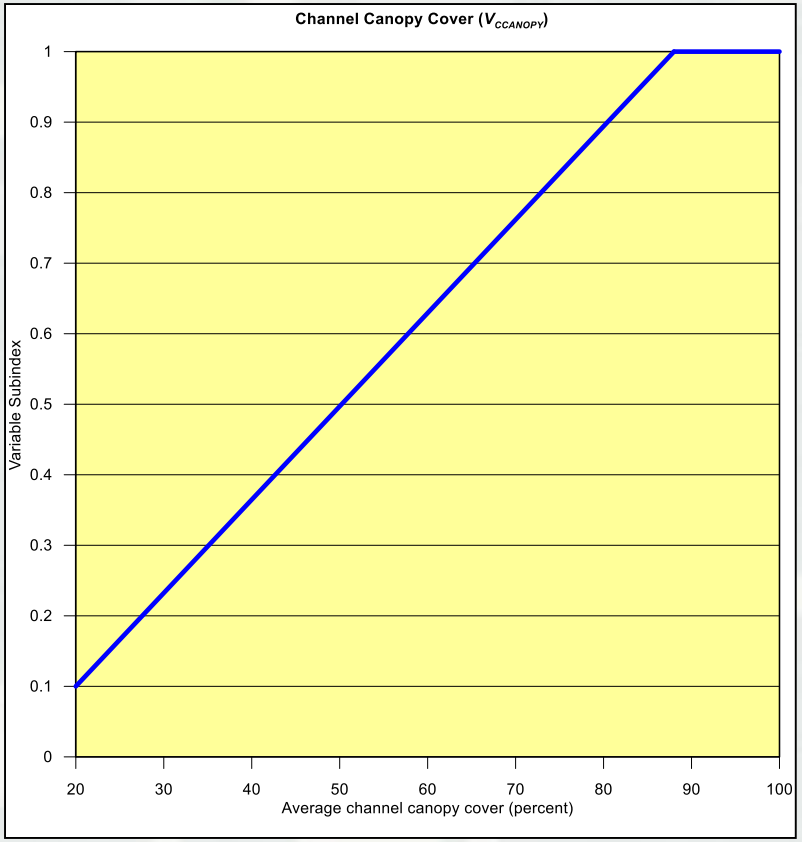
- Average percent cover of vegetation over the stream channel
- Only used for stream reaches with >20% canopy cover
- Canopy cover ≥88% receives score 1.0
- Only used in the wildlife habitat function

How to Measure Channel Canopy Cover

- Measure using a densiometer while standing in the stream
- Measure at 10 points along stream reach

Channel Canopy Cover Variable Scaling – Headwater Streams

- Subindex is never 0



Channel Substrate Embeddedness – Headwater Streams

(V_{EMBED})

- Average embeddedness index of stream substrate
- Embeddedness ratings between 3.5 and 4 receive a score of 1.0

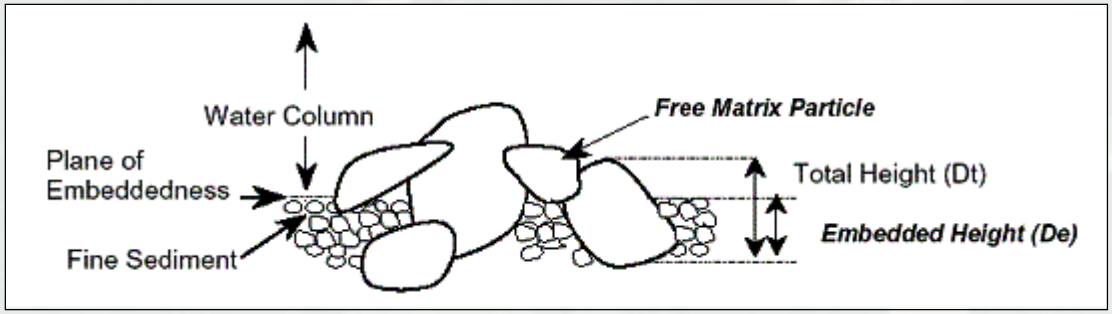
Table 1
Embeddedness rating for gravel, cobble, and boulder particles (rescaled from Platts et al. 1983)

Rating	Rating Description
5	<5 percent of surface covered, surrounded, or buried by fine sediment (or bedrock)
4	5 to 25 percent of surface covered, surrounded, or buried by fine sediment
3	26 to 50 percent of surface covered, surrounded, or buried by fine sediment
2	51 to 75 percent of surface covered, surrounded, or buried by fine sediment
1	>75 percent of surface covered, surrounded, or buried by fine sediment (or artificial substrate)

- Used in hydrology, biogeochemistry and habitat functions

How to Measure Embeddedness

- Measure at least 30 points along stream reach
- Randomly select a particle from the stream bed
- Visually estimate percentage of the particle that is covered, surrounded or buried with fine materials



Embeddedness Examples

Category 5: Bedrock

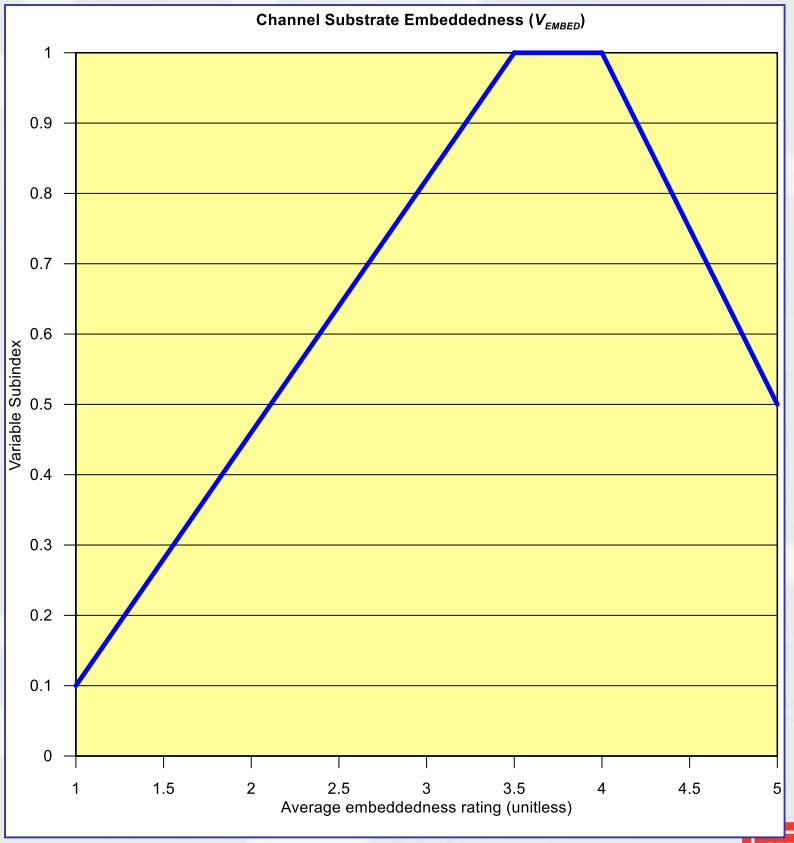
Category 4: 5-25% covered

Category 1: >75% covered

Category 3: 26-50% covered

Embeddedness Variable Scaling – Headwater Streams

- Subindex is never 0



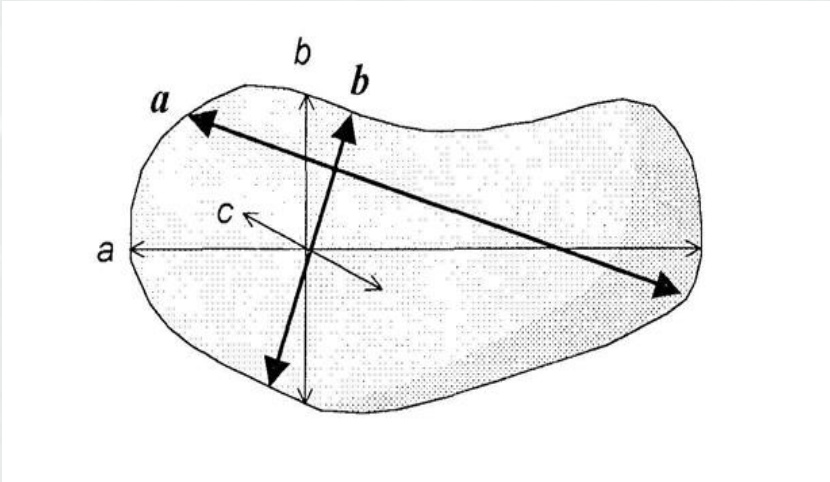
Channel Substrate Size – Headwater Streams

($V_{SUBSTRATE}$)

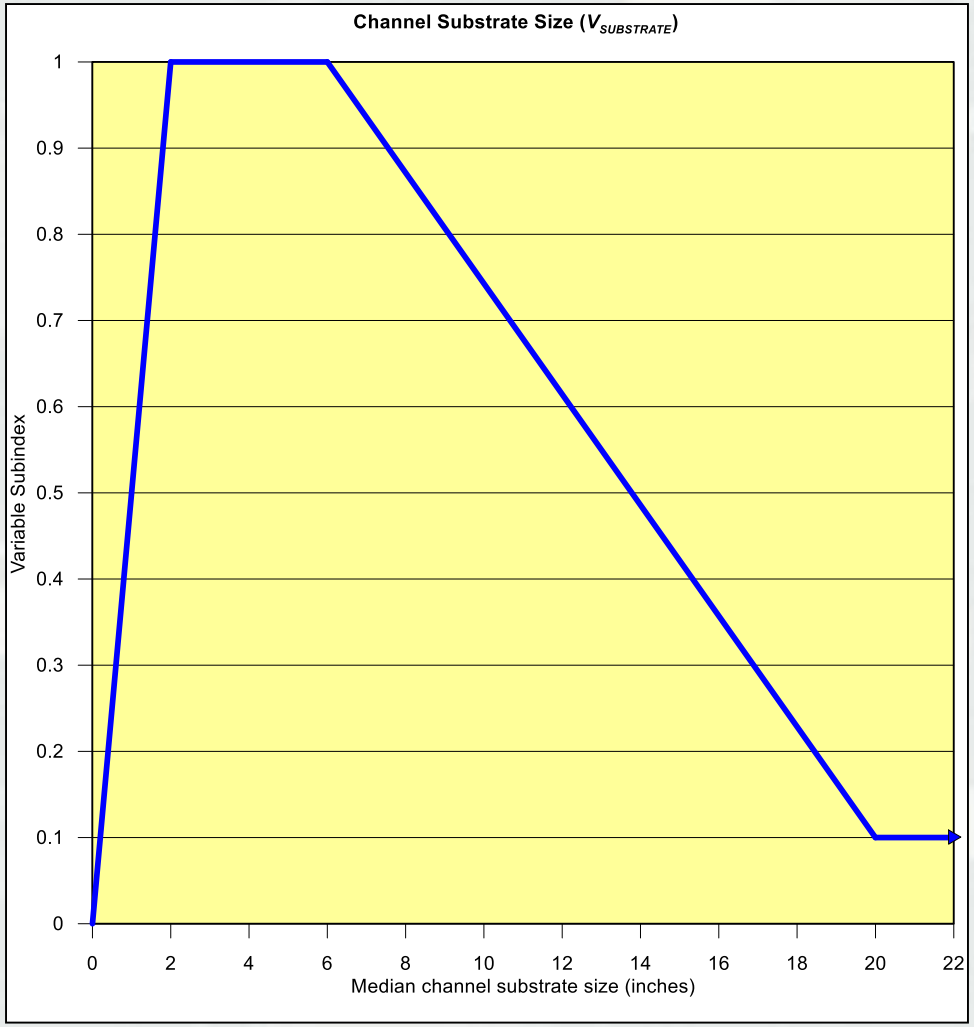
- Median substrate size of bed material in the stream channel
- Median substrate size between 2 and 6 in. receives a score of 1.0
- Used in hydrology and habitat functions for headwater streams

How to Measure Substrate Size

- Measure at the same time as embeddedness
- Randomly select a particle from the stream bed
- Measure the median (b) axis to the nearest 0.1 in
- Bedrock = 99 in
- Concrete or asphalt = 0 in
- Sand or finer = 0.08 in



Channel Substrate Size Variable Scaling – Headwater Streams



Channel Bank Erosion

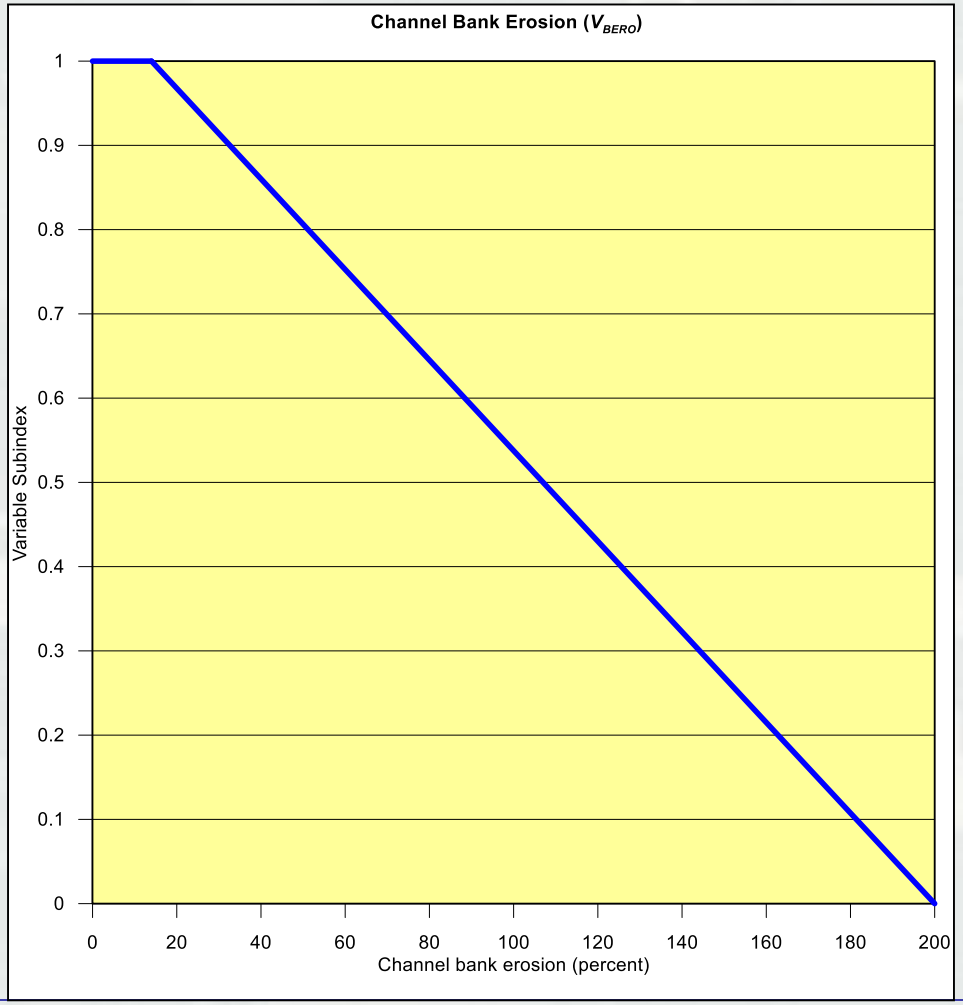
(V_{BERO})

- Proportion of stream channel with eroded bank
- Ranges from 0 to 200 percent
- Less than 14% eroded bank receives a score of 1.0
- Used in hydrology, biogeochemistry and habitat functions for headwater streams

How to Measure Channel Bank Erosion

- While standing in the channel, measure erosion length on both the left and right streambanks

Channel Bank Erosion Variable Scaling



Large Woody Debris – Headwater Streams

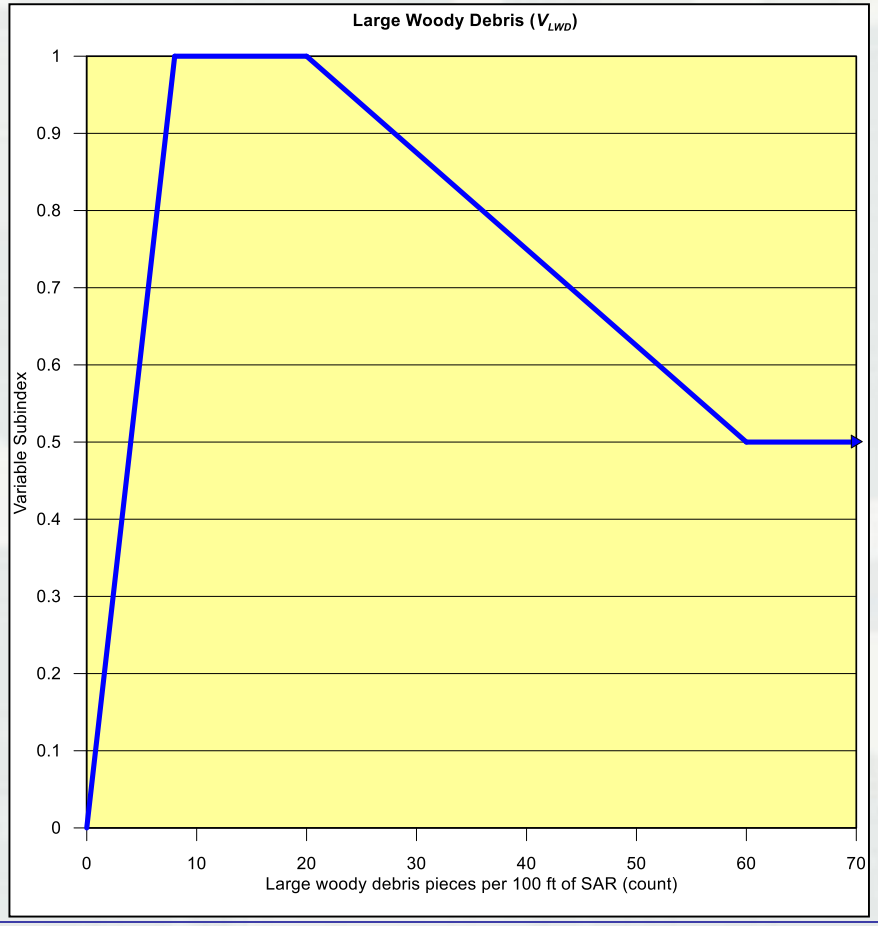
(V_{LWD})

- Number of down woody stems in the riparian/buffer zone per 100 ft of stream reach
- At least 4 in. diameter and 36 in. long
- Streams with 8-20 pieces of LWD receive a score of 1.0
- Used in the hydrology, biogeochemistry and habitat functions for headwater streams

How to Measure Large Woody Debris

- Measure within the riparian/buffer zone, extending 25 ft on either side of the channel
- Count each piece of LWD along the entire stream assessment reach
- Count broken logs as one piece

Large Woody Debris Variable Scaling – Headwater Streams



Riparian/Buffer Zone Tree Diameter – Headwater Streams

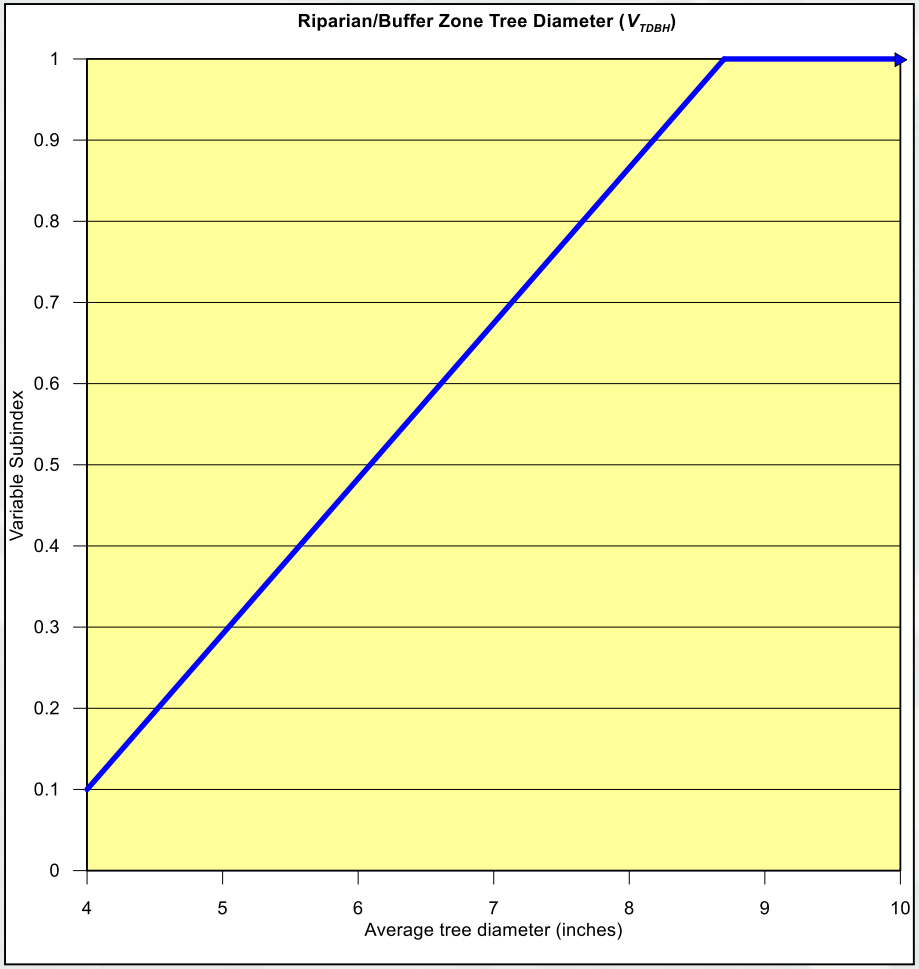
(V_{TDBH})

- Average diameter at breast height (DBH) of trees within the riparian/buffer zone
- Stream reaches with average DBH of $\geq$8.7 in. receive a score of 1.0
- Used in the biogeochemistry and habitat functions for headwater streams

How to Measure Tree Diameter – Headwater Streams

- Use a calipers or DBH tape to measure diameter of all trees at least 4 in. DBH
- Measure all trees within the riparian/buffer zone, extending 25 ft on either side of the channel

Riparian/Buffer Zone Tree Diameter Variable Scaling



Riparian/Buffer Zone
Snag Density

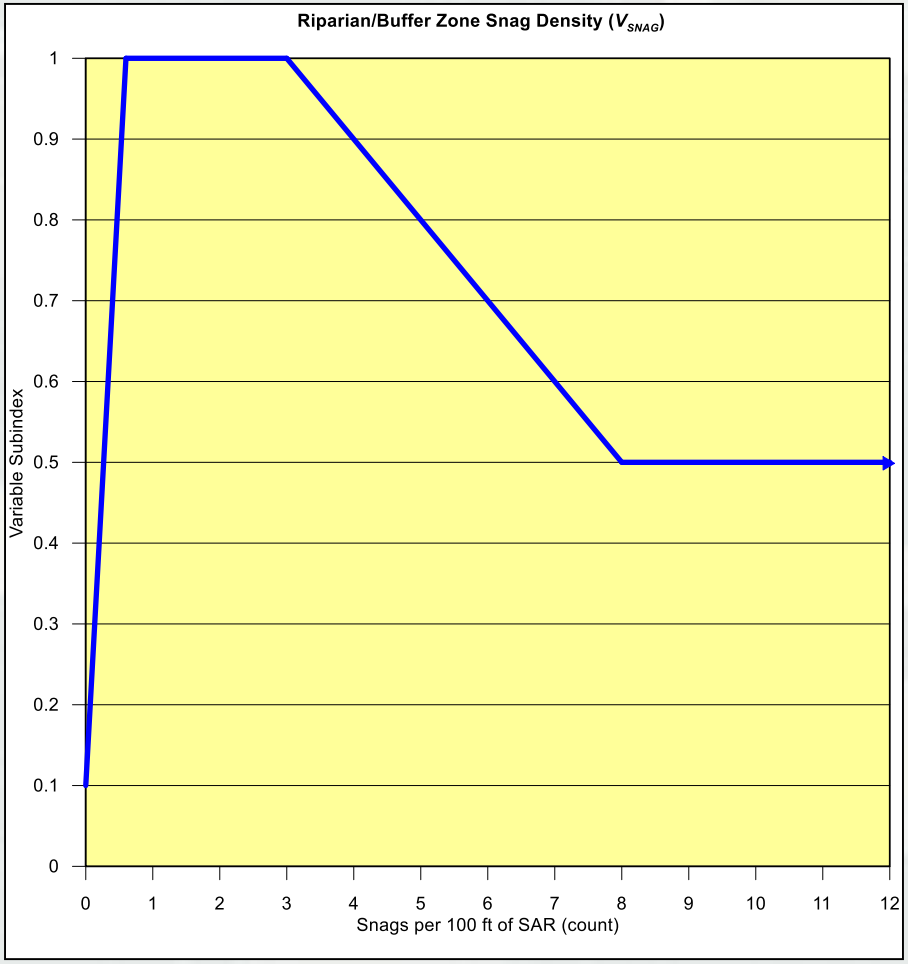
(V_{SNAG})

- Number of snags per 100 ft of stream assessment reach
- Stream reaches with 0.6-3 snags per 100 ft receive a score of 1.0
- Used only in the habitat function for headwater streams

How to Measure Snag Density

- Count all snags at least 4 in. diameter and 36 in. high
- Measure snags within the riparian/buffer zone, extending 25 ft on either side of the channel

Riparian/Buffer Zone Snag Density Variable Scaling



Riparian/Buffer Zone Sapling/Shrub Density

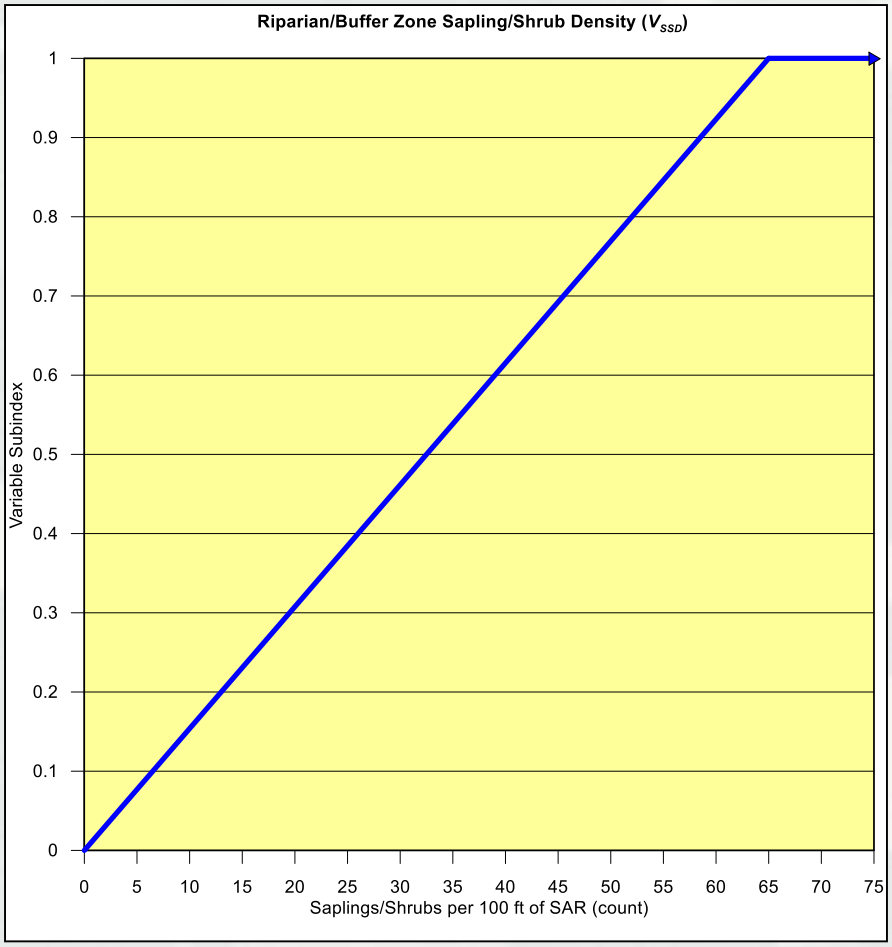
(V_{SSD})

- Density of woody stems at least 36 in. high and less than 4 inches DBH
- Used only for stream reaches with <20% canopy cover
- Stream reaches with ≥65 stems per 100 ft of stream reach receive a score of 1.0
- Used in the biogeochemistry and habitat functions for headwater streams

How to Measure Sapling/Shrub Density

- Measure only at stream reaches where canopy cover is <20%
- Count all sapling and shrub stems within the riparian/buffer zone, extending 25 ft on either side of the channel
- Does not include herbaceous plants or woody vines

Riparian/Buffer Zone Sapling/Shrub Density Variable Scaling



Riparian/Buffer Zone Vegetation Species Richness (V_{SRICH})

- Index reflecting richness of native tree species (group 1)
- Downgrades stream reaches for each exotic plant species in any stratum (group 2)

$$\text{Riparian/Buffer Zone Species Richness} = \left[\frac{(\text{Group 1 species} - \text{Group 2 species})}{\text{Total length of SAR (ft)}} \times 100\right] \times \left[1 - \left(\frac{10 \times \text{Group 2 species}}{\text{Total length of SAR (ft)}}\right)\right]$$

- Stream reaches with species richness of at least 2.1 receive a score of 1.0
- Used only in the habitat function for headwater streams

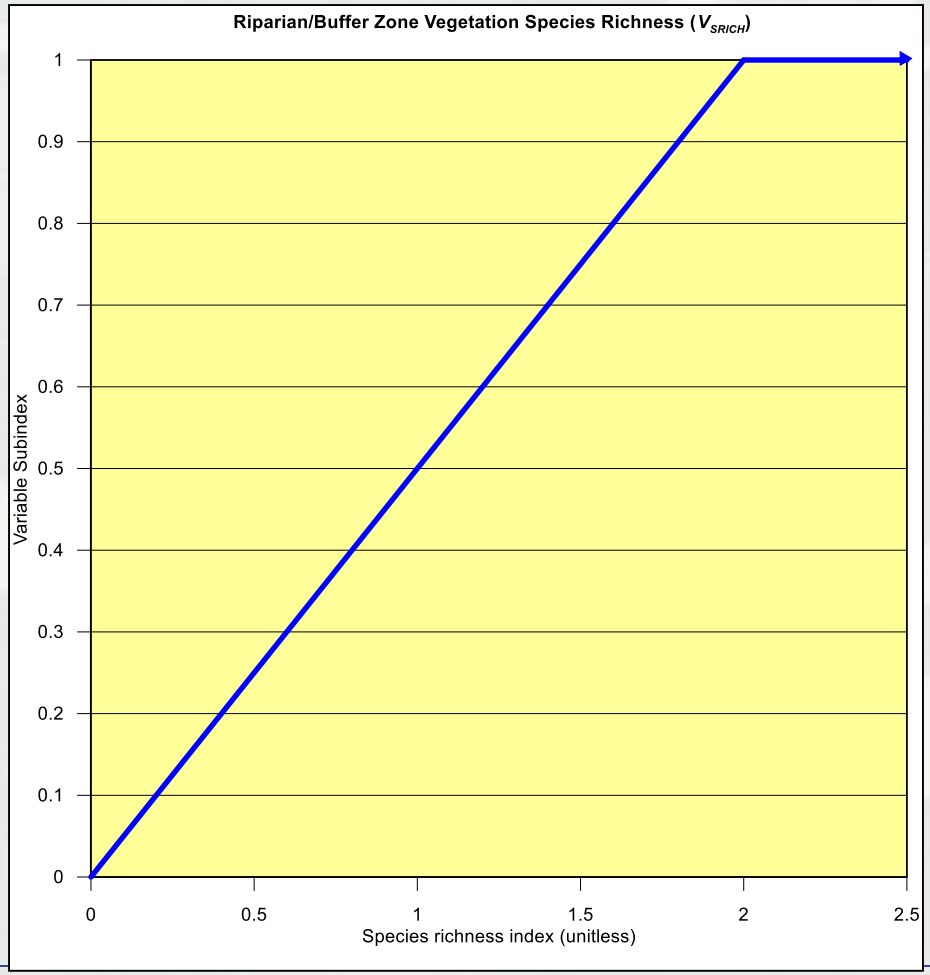
Table 3
Species used to calculate V_{SRICH} in the riparian/buffer zone of headwater streams

Scientific Name	Common Name	*Scientific Name*	Common Name
Group 1		Group 2	
Acer pensylvanicum	striped maple	*Ailanthus altissima*	tree of heaven
Acer rubrum	red maple	*Albizia julibrissin*	silktree
Acer saccharum	sugar maple	*Alliaria petiolata*	garlic mustard
Aesculus flava	yellow buckeye	*Alternanthera philoxeroides*	Alligator weed
Asimina triloba	pawpaw	*Aster tataricus*	tatarian aster
Betula alleghaniensis	yellow birch	*Cerastium fontanum*	common mouse-ear
Betula lenta	black birch	*Coronilla varia*	crown vetch
Carya cordiformis	bitternut hickory	*Elaeagnus umbellata*	autumn olive
Carya glabra	pignut hickory	*Lespedeza bicolor*	shrub lespedeza
Carya ovata	shagbark hickory	*Lespedeza cuneata*	sericea lespedeza
Carya tomentosa	mockernut hickory	*Ligustrum obtusifolium*	border privet
Cornus	flowering dogwood	*Ligustrum sinense*	Chinese privet
Fagus grandifolia	American beech	*Lonicera japonica*	Japanese honeysuckle
Fraxinus	white ash	*Lonicera tatarica*	Tatarian honeysuckle
Liriodendron tulipifera	tuliptree	*Lotus corniculatus*	bird's-foot trefoil
Magnolia acuminata	cucumber-tree	*Lythrum salicaria*	purple loosestrife
Magnolia tripetala	umbrella-tree	*Microstegium vimineum*	Nepalese browntop
Nyssa sylvatica	blackgum	*Paulownia tomentosa*	princesstree
Oxydendrum arboreum	sourwood	*Fallopia japonica*	Japanese knotweed
Pinus strobus	eastern white pine	*Pueraria montana*	kudzu
Prunus serotina	black cherry	*Rosa multiflora*	multiflora rose
Quercus alba	white oak	*Sorghum halepense*	Johnsongrass
Quercus coccinea	scarlet oak	*Verbena brasiliensis*	Brazilian vervain
Quercus imbricaria	shingle oak		
Quercus montana	chestnut oak		
Quercus rubra	northern red oak		
Quercus velutina	black oak		
Sassafras albidum	sassafras		
Tilia	American basswood		
Tsuga canadensis	eastern hemlock		
Ulmus	American elm		

How to Measure Species Richness

- Check off each tree species present in Group 1 within the riparian/buffer zone, extending 25 ft on either side of the channel
- If canopy cover ≤20%, use the sapling/shrub stratum
- Check off all exotic species from any strata

Riparian/Buffer Zone Vegetation Species Richness Variable Scaling



Riparian/Buffer Zone Soil Detritus

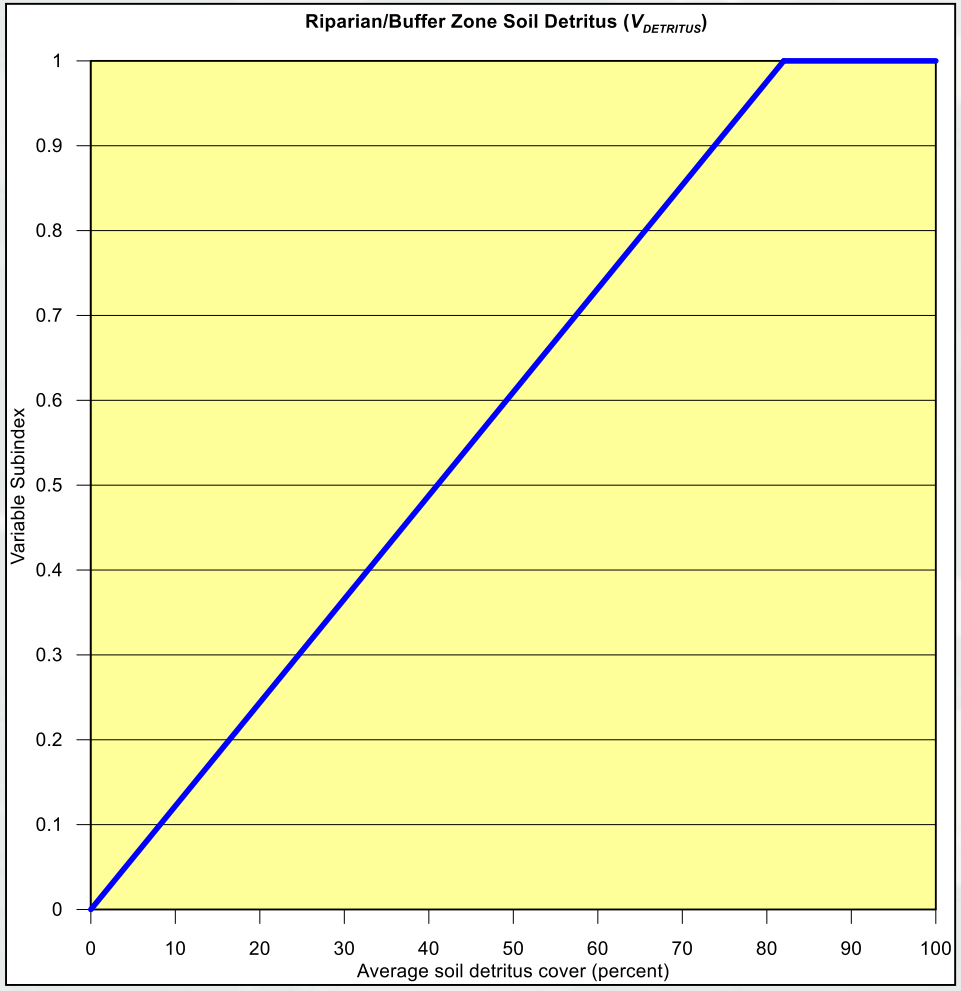
($V_{DETRITUS}$)

- Average percent cover of detrital material on the soil surface within the riparian/buffer zone
- Organic material (e.g., leaf litter, sticks, needles, flowers, fruits)
- Stream reaches with at least 82% detritus cover receive a score of 1.0
- Used in the biogeochemistry and habitat functions for headwater streams

How to Measure Soil Detritus

- Visually estimate percent cover of organic material within at least 8 representative 1m^2 plots in the riparian/buffer zone

Riparian/Buffer Zone Soil Detritus Variable Scaling



Riparian/Buffer Zone Herbaceous Cover

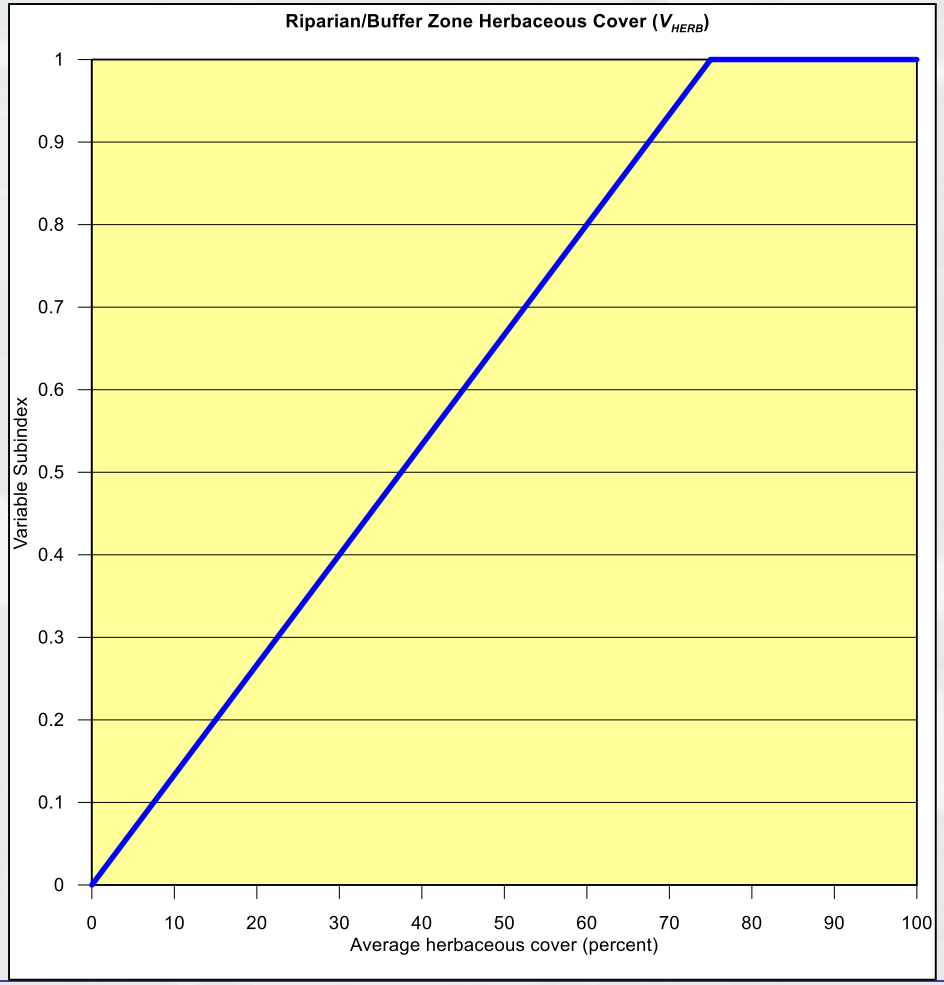
(V_{HERB})

- Average percent cover of herbaceous vegetation in the riparian/buffer zone
- Used only for stream reaches with <20% canopy cover
- Stream reaches with ≥75% receive a score of 1.0
- Used in the biogeochemistry and habitat functions for headwater streams

How to Measure Herbaceous Cover

- Measure only at stream reaches where canopy cover is <20%
- Visually estimate percent cover of organic material within the same $1m^2$ plots used for Soil Detritus

Riparian/Buffer Zone Herbaceous Cover Variable Scaling



Watershed Land-use

(V_{WLUSE})

- Weighted average of land-use indices in watershed
- Reflects surface runoff potential
- Land-use type is multiplied by a land-use index
- Stream reaches with a land-use ≥75 receive a score of 1.0
- Used in the hydrology, biogeochemistry and habitat functions for headwater streams

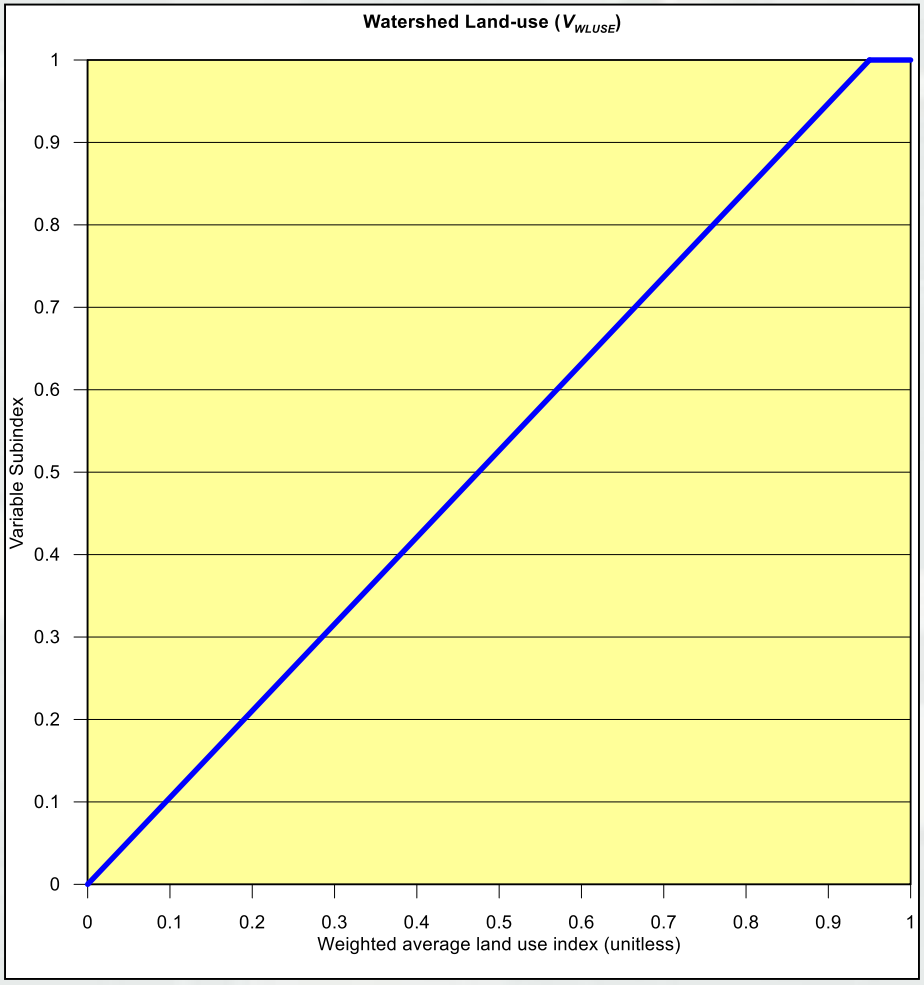
How to Measure Watershed Land-use

- Delineate watershed using topographic maps, aerial photos, or other methods
- Estimate percent cover of land-use types using remote techniques, verify in the field

Table 4
Watershed Land-use

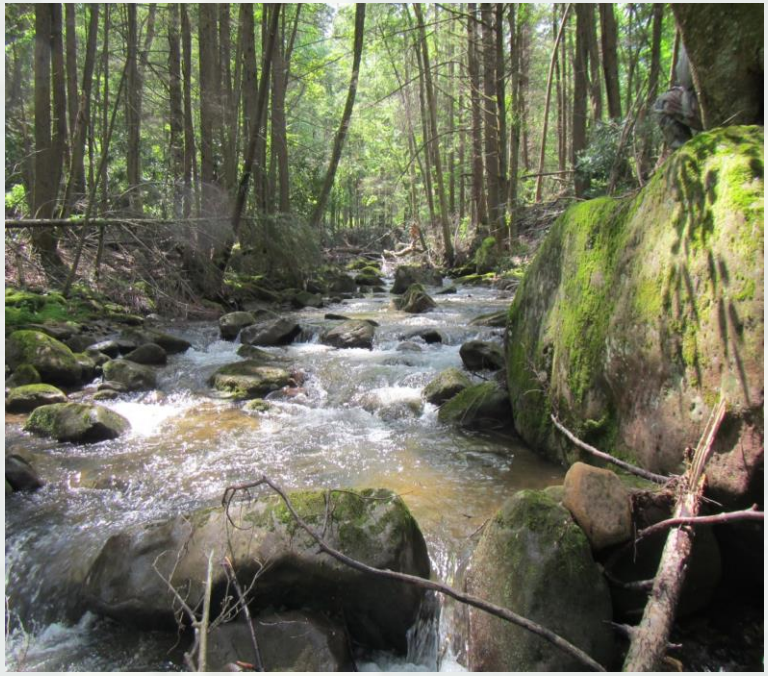
Land-use type	Land-use index
Forest and native range	1.0
Low density residential (≥1 acre lots)	0.3
Open space (pasture, lawns, parks, golf courses, cemeteries):	0.2
High density residential (<1 acre lots)	0.1
Impervious areas (parking lots, roofs, driveways, etc)	0
Gravel	0
Industrial, commercial and business	0
Newly graded areas (bare soil, no vegetation or pavement)	0

Watershed Land-use Variable Scaling



Assessment Variables – Perennial Streams

- Channel Canopy Cover
- Channel Substrate Embeddedness
- Channel Substrate Size
- Streambank Stability
- Large Woody Debris
- Riparian/Buffer Zone Tree Diameter
- Riparian/Buffer Zone Tree Density
- Coefficient of Conservatism
- Watershed Forest Cover



Assessment Variables – Perennial Sampling Locations

Watershed Variables

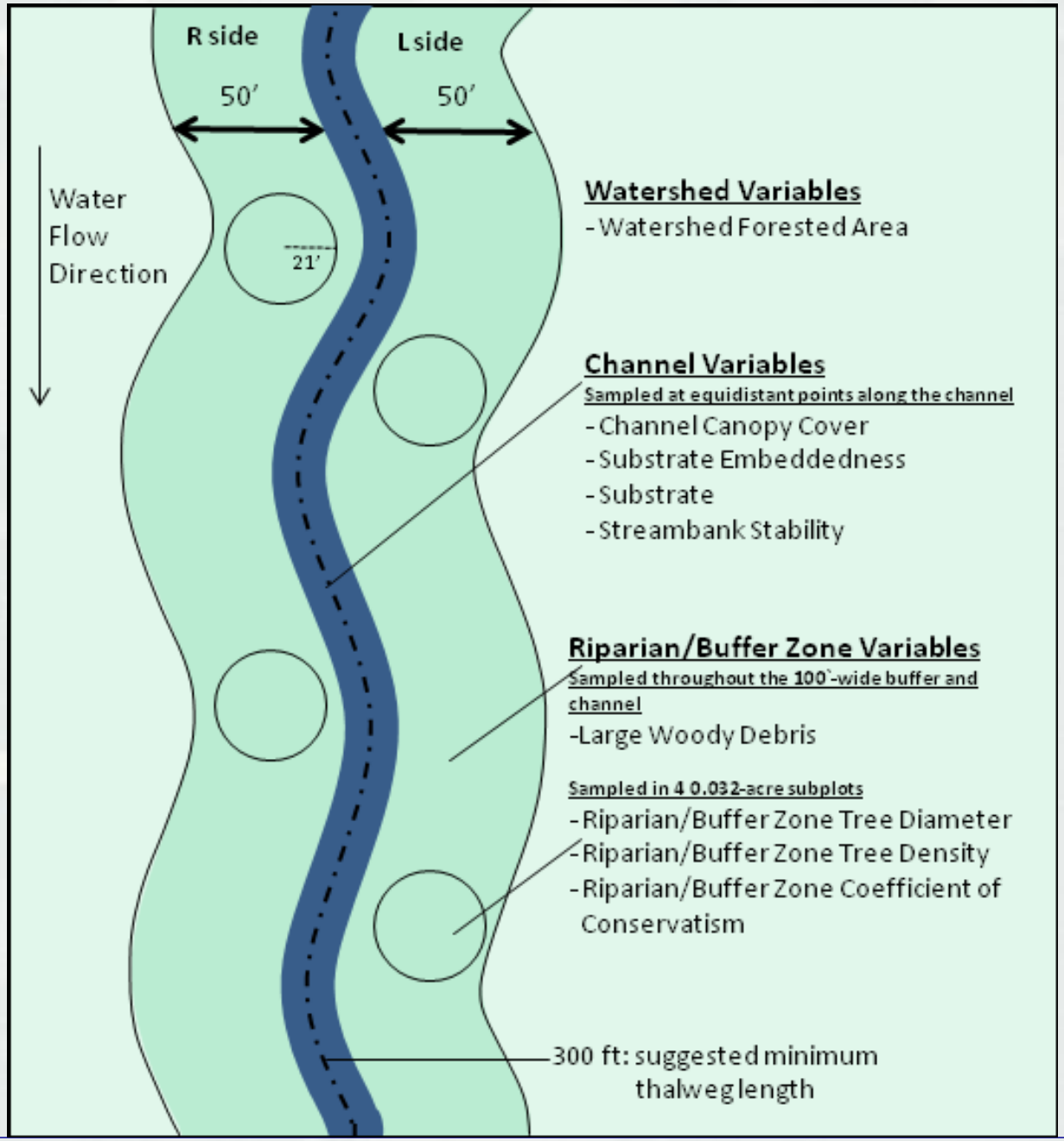
- Watershed Forested Area

Channel Variables

- Canopy Cover
- Substrate Embeddedness
- Substrate Size
- Streambank Stability

Riparian/Buffer Zone Variables

- Large Woody Debris
- Tree Diameter
- Tree Density
- Coefficient of Conservatism


R side
L side
50′
50′
Water
Flow
Direction
21′
Watershed Variables
- Watershed Forested Area
Channel Variables
Sampled at equidistant points along the channel
- Channel Canopy Cover
- Substrate Embeddedness
- Substrate
- Streambank Stability
Riparian/Buffer Zone Variables
Sampled throughout the 100`-wide buffer and channel
-Large Woody Debris
Sampled in 4 0.032-acre subplots
- Riparian/Buffer Zone Tree Diameter
- Riparian/Buffer Zone Tree Density
- Riparian/Buffer Zone Coefficient of Conservatism
300 ft: suggested minimum thalweg length

Channel Canopy Cover – Perennial Streams

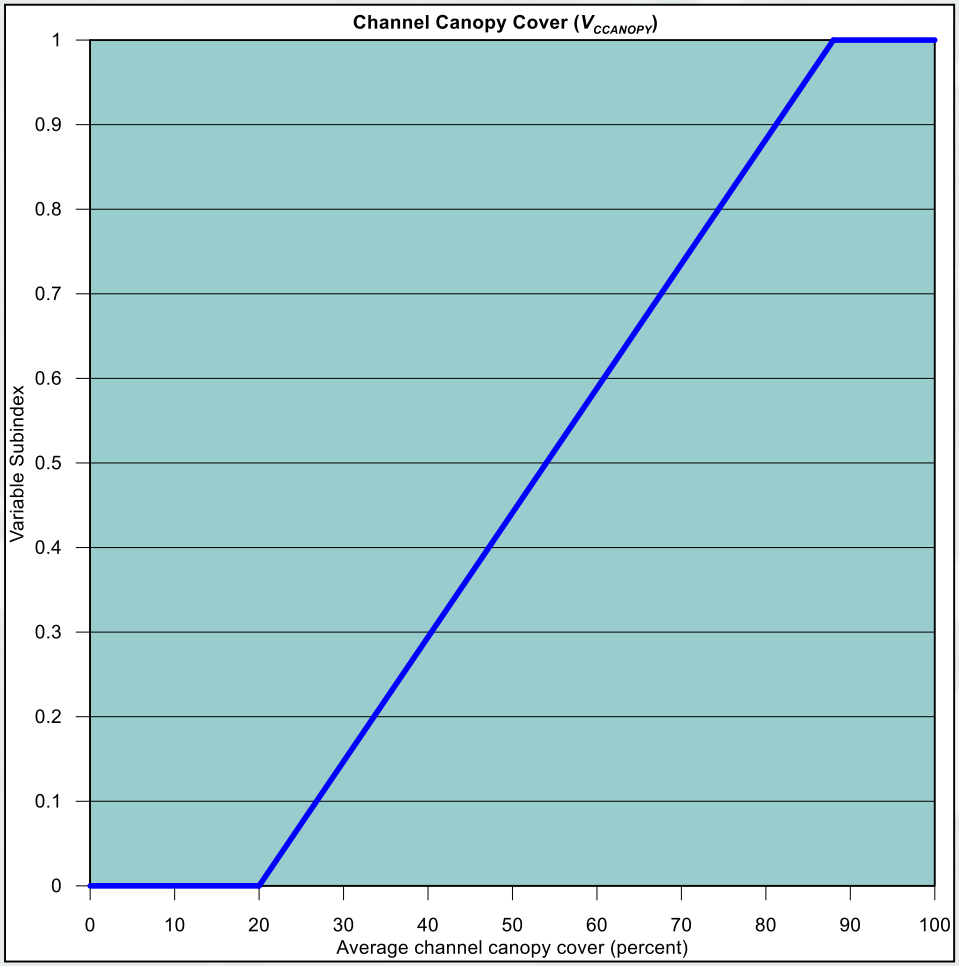
($V_{CCANOPY}$)

- Average percent cover of vegetation over the stream channel
- Used for all perennial stream reaches, even those with <20% canopy
- Canopy cover ≥87% receives score 1.0
- Only used in the wildlife habitat function

How to Measure Channel Canopy Cover

- Measurement is the same as for headwater streams
- Measure using a densiometer while standing in the stream
- Measure at 10 points along stream reach

Channel Canopy Cover Variable Scaling – Perennial Streams



Channel Substrate Embeddedness – Perennial Streams

(V_{EMBED})

- Average embeddedness index of stream substrate
- Average embeddedness ratings >4.15 receive a score of 1.0

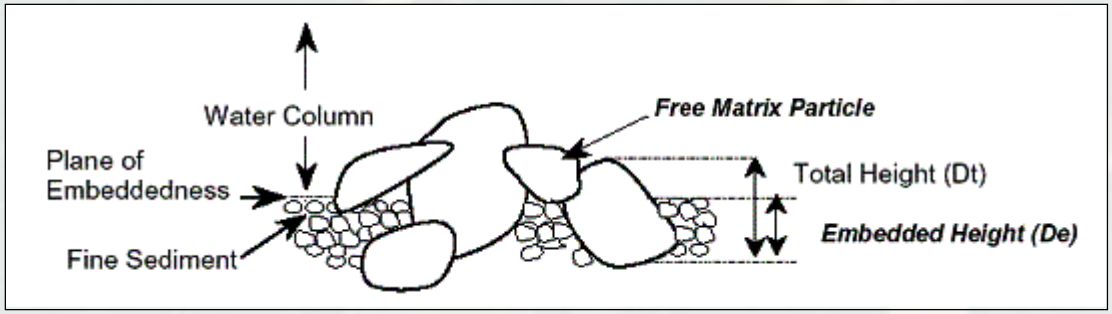
Table 1
Embeddedness rating for gravel, cobble, and boulder particles (rescaled from Platts et al. 1983)

Rating	Rating Description
5	<5 percent of surface covered, surrounded, or buried by fine sediment (or bedrock)
4	5 to 25 percent of surface covered, surrounded, or buried by fine sediment
3	26 to 50 percent of surface covered, surrounded, or buried by fine sediment
2	51 to 75 percent of surface covered, surrounded, or buried by fine sediment
1	>75 percent of surface covered, surrounded, or buried by fine sediment (or artificial substrate)

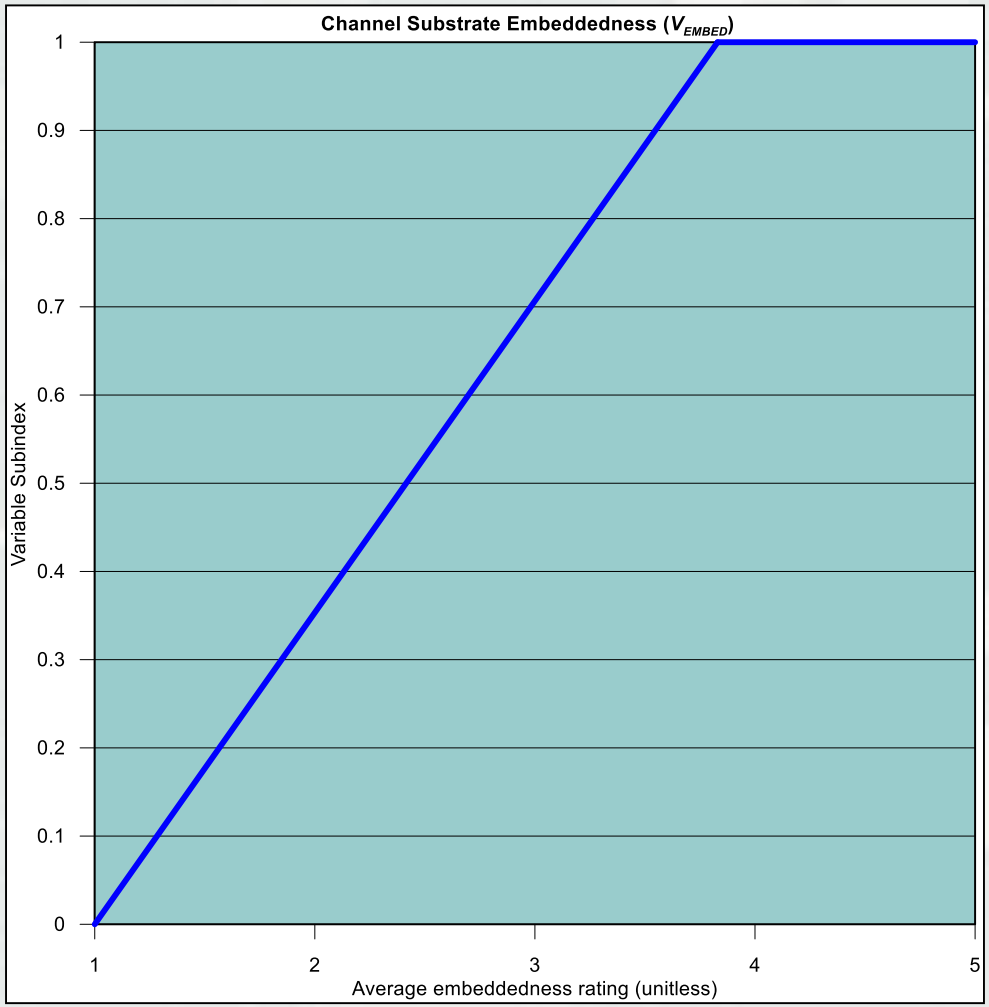
- Used in hydrology, biogeochemistry and habitat functions

How to Measure Embeddedness

- Measure at least 60 points along stream reach
- Measurement same as in headwater streams
- Randomly select a particle from the stream bed
- Visually estimate percentage of the particle that is covered, surrounded or buried with fine materials



Embeddedness Variable Scaling – Perennial Streams



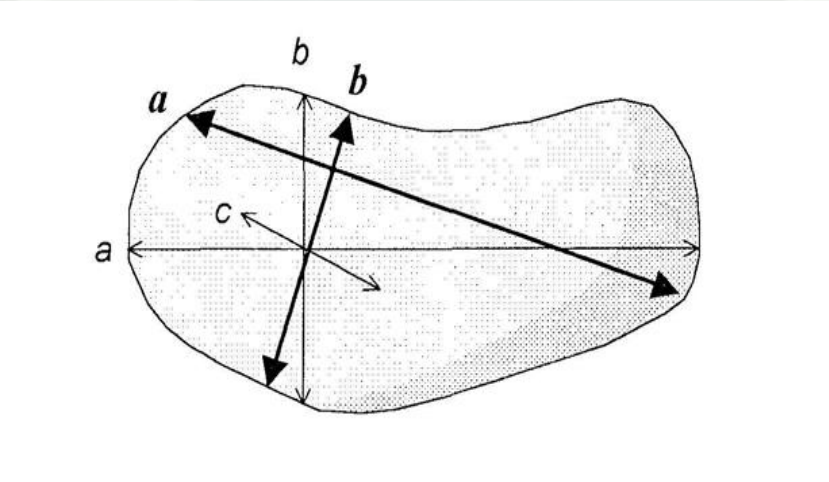
Channel Substrate Size – Perennial Streams

($V_{SUBSTRATE}$)

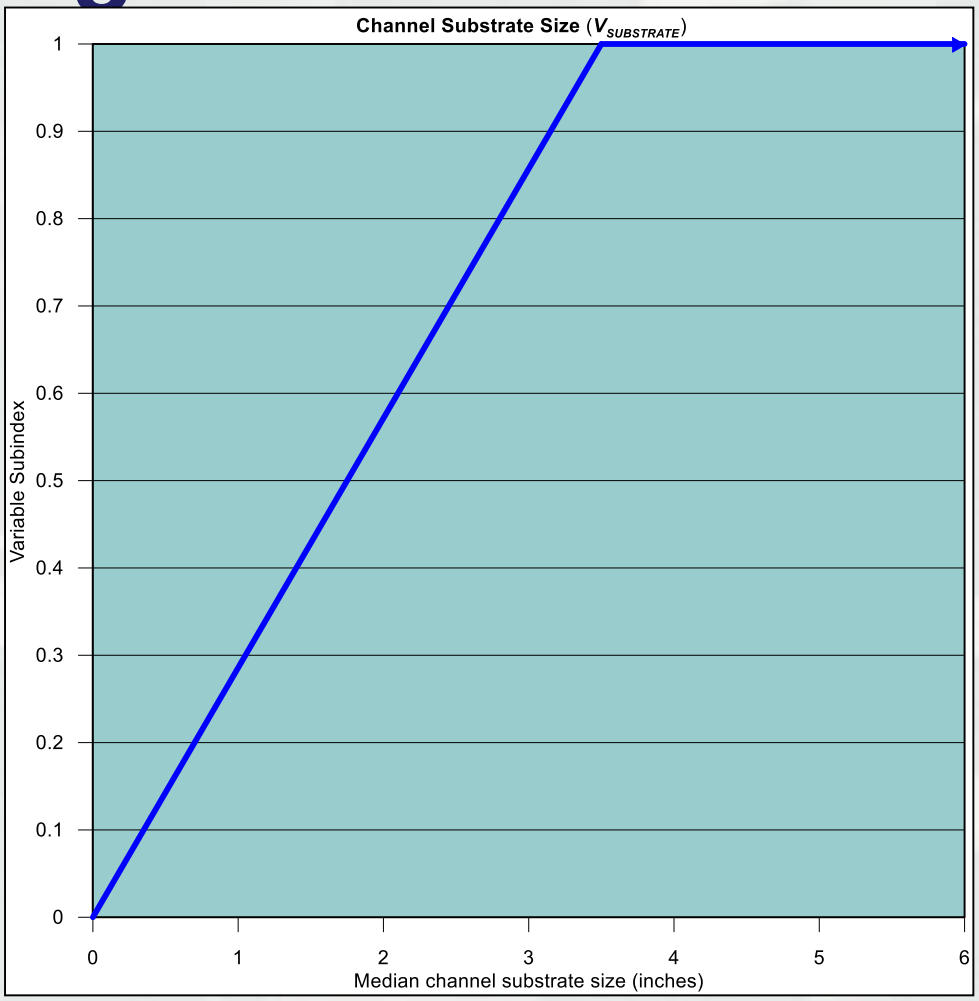
- Median substrate size of bed material in the stream channel
- Median substrate size >3.9 in receives a score of 1.0
- Used in hydrology, biogeochemistry and habitat functions for perennial streams

How to Measure Substrate Size

- Measure at the same time as embeddedness
- Randomly select a particle from the stream bed
- Measure the median (b) axis to the nearest 0.1 in
- Bedrock = 99 in
- Concrete or asphalt = 0 in
- Sand or finer = 0.08 in



Channel Substrate Size Variable Scaling – Perennial Streams



Streambank Stability

($V_{BANKSTAB}$)

- Index reflecting streambank integrity
  - Percentage of eroded streambank length
  - Height category of eroded bank
  - Amount of artificially stabilized bank

$$\text{Streambank Stability} = 100 \sum_{i=1}^{n} \left(\frac{\text{bank length}_i \times \text{erosion multiplier}_i}{\text{SAR length}} \right)$$

- Values range from 0 to 200
- Less than 15 receives a score of 1.0
- Used in the hydrology function for perennial streams

How to Measure Streambank Stability

- While standing in the channel, measure length of each section of erosion above bankfull level
- Assign height category to each eroded area
- Erosion length is multiplied by height category multiplier

Table 2. Erosion height rating for calculating Streambank Stability in perennial streams

Height of erosion above bankfull stage (ft)	Height category	Erosion multiplier
0.1–2	1	0.5
2.1–4	2	0.7
>4	3	1
Artificial Bank Stabilization	4	0.5

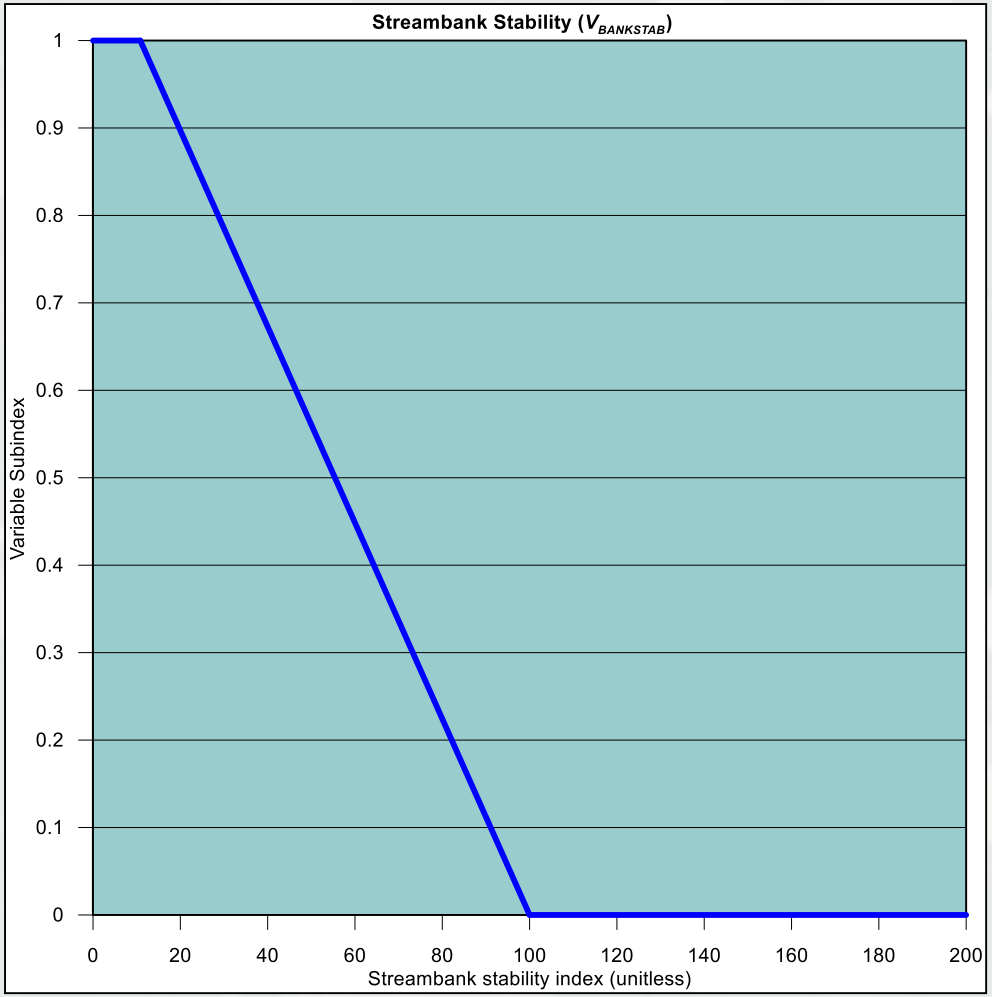
Erosion 1-2 ft above bankfull

Erosion 2.1-4 ft above bankfull

Erosion >4 ft above bankfull

Artificial stabilization

Streambank Stability Variable Scaling



Large Woody Debris – Perennial Streams

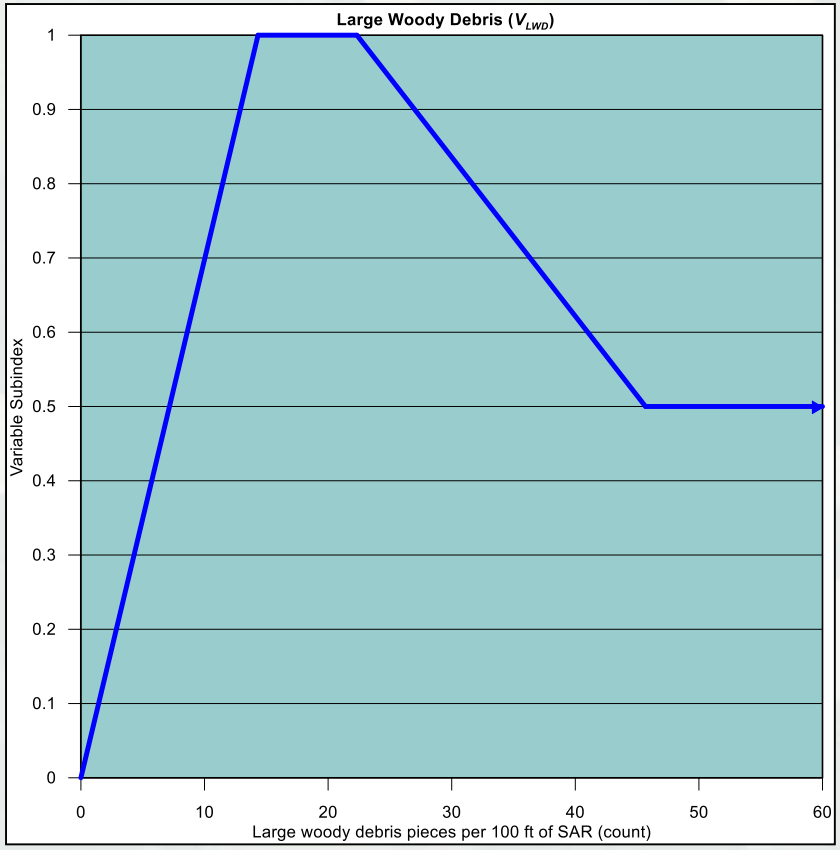
(V_{LWD})

- Number of down woody stems in the riparian/buffer zone per 100 ft of stream reach
- At least 4 in. diameter and 36 in. long
- Streams with 14-22 pieces of LWD receive a score of 1.0
- Used only in the habitat function for perennial streams

How to Measure Large Woody Debris

- Measure within the riparian/buffer zone, extending 50 ft on either side of the channel
- Count each piece of LWD along the entire stream assessment reach and channel
- Count broken logs as one piece

Large Woody Debris Variable Scaling – Perennial Streams



Riparian/Buffer Zone Tree Diameter – Perennial Streams

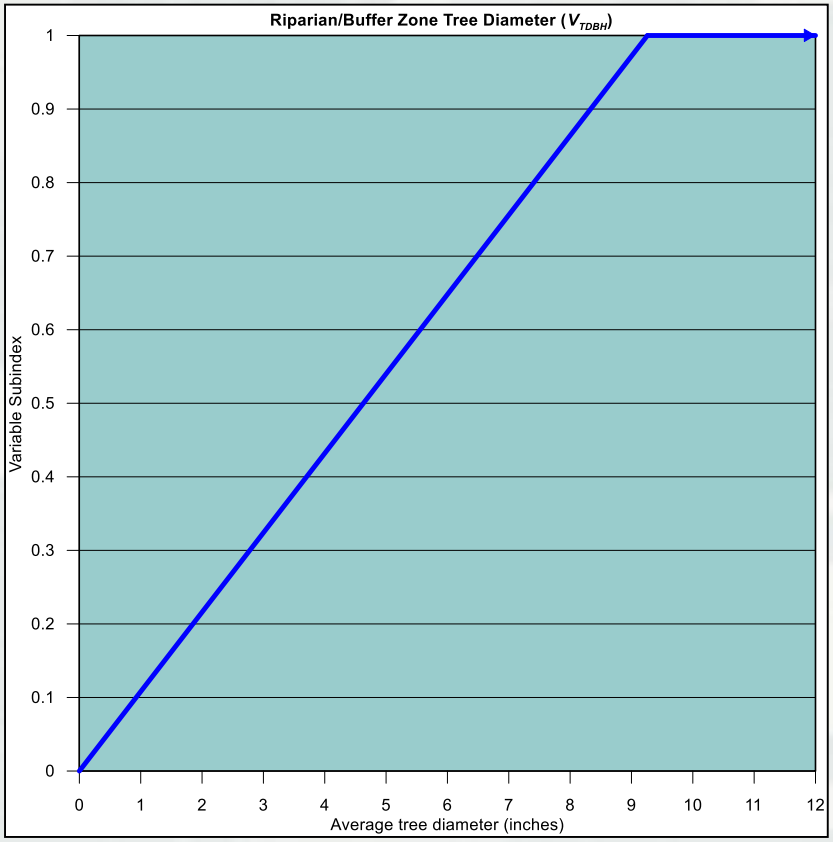
(V_{TDBH})

- Average diameter at breast height of trees within the riparian/buffer zone
- Stream reaches with average DBH of $\geq$9.3 in. receive a score of 1.0
- Used in the habitat function for perennial streams

How to Measure Tree Diameter – Perennial Streams

- Select 4, 21-ft radius plots within 50 ft of the channel edge
- Use a calipers or DBH tape to measure diameter of all trees within subplots at least 4 in. DBH

Riparian/Buffer Zone Tree Diameter Variable Scaling – Perennial Streams



Riparian/Buffer Zone Tree Density

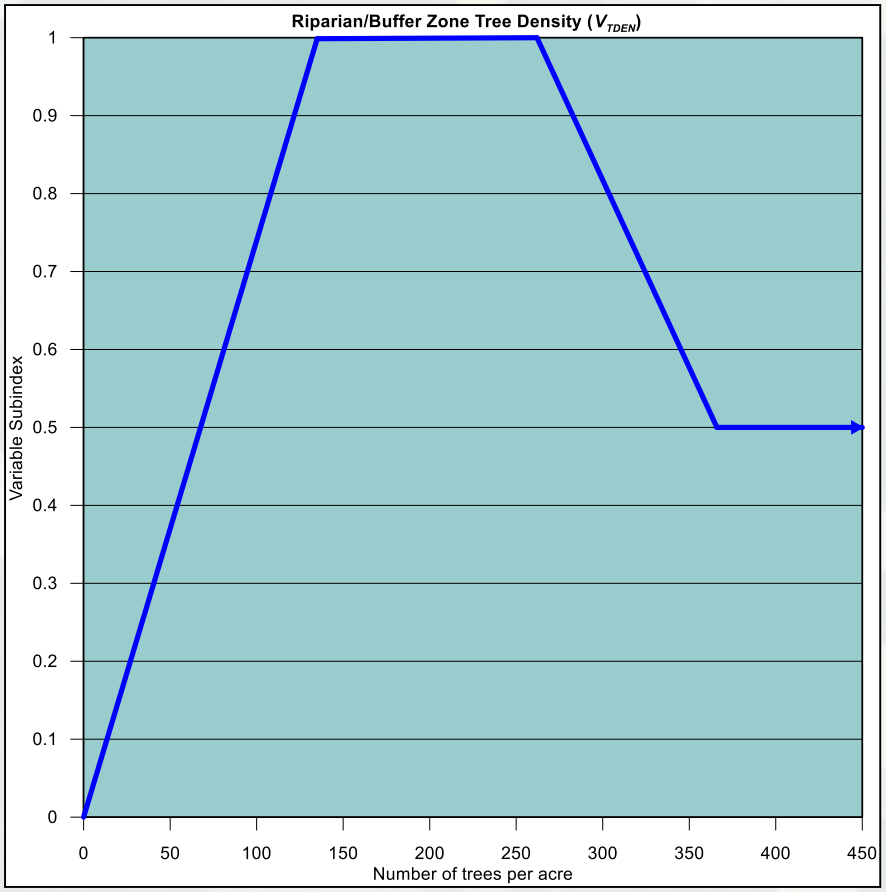
(V_{TDEN})

- Average number of trees ≥4 in. diameter per acre
- Measured in at least 4, 0.032-acre subplots within the riparian/buffer zone
- Stream reaches with 135-262 trees/acre receive a score of 1.0
- Used in the biogeochemistry function for perennial streams

How to Measure Tree Density

- Measured along with tree diameter
- When measuring diameter, total the number of trees within the 4, 21-ft radius subplots

Riparian/Buffer Zone Tree Density Variable Scaling



Coefficient of Conservatism

(V_{CVALUE})

- Average of published C-values for trees and all non-native vegetation
- Ranking of 0-10 published by the WV Natural Heritage Program
- Reflects tolerance to disturbance
- Exotic species receive C-values of 0
- Measured within 0.032-acre subplots
- Average C-values >5.5 receive a score of 1.0

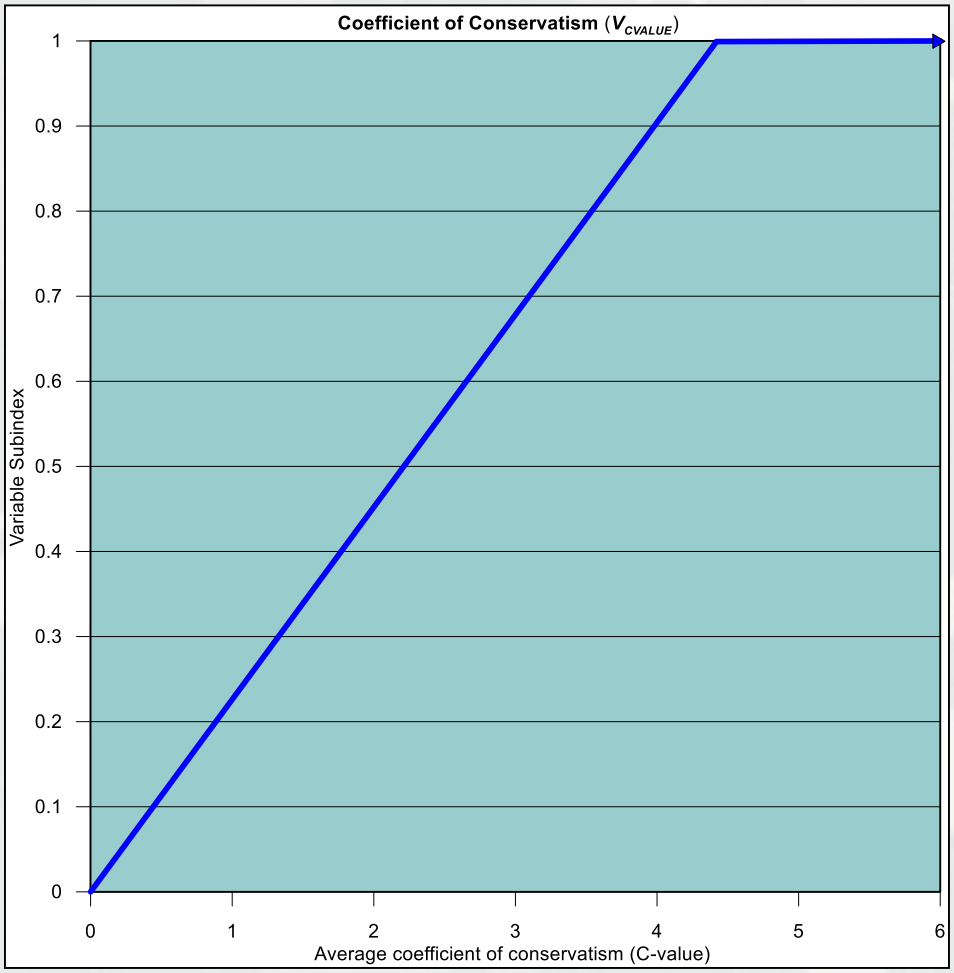
How to Measure Coefficient of Conservatism

- In the 4, 21-ft radius subplots, list each tree species found
- List any non-native species in any strata (herbaceous, shrub, sapling, trees)
- Assign provided C-values in (Table B1)

Example C-values

Table B1. Coefficients of Conservatism for common trees		
Common Name	**Scientific Name**	**C-value**
boxelder maple	*Acer negundo*	2
black maple	*Acer nigrum*	7
red maple	*Acer rubrum*	3
sugar maple	*Acer saccharum*	6
yellow buckeye	*Aesculus flava*	7
common serviceberry	*Amelanchier arborea*	6
pawpaw	*Asimina triloba*	5
yellow birch	*Betula alleghaniensis*	7
sweet birch	*Betula lenta*	5
river birch	*Betula nigra*	5
American hornbeam	*Carpinus caroliniana*	5
mockernut hickory	*Carya alba*	6
bitternut hickory	*Carya cordiformis*	5
pignut hickory	*Carya glabra*	6
shagbark hickory	*Carya ovata*	6
Japanese barberry	*Berberis thunbergii*	0

Coefficient of Conservatism Variable Scaling



Watershed Forest Cover

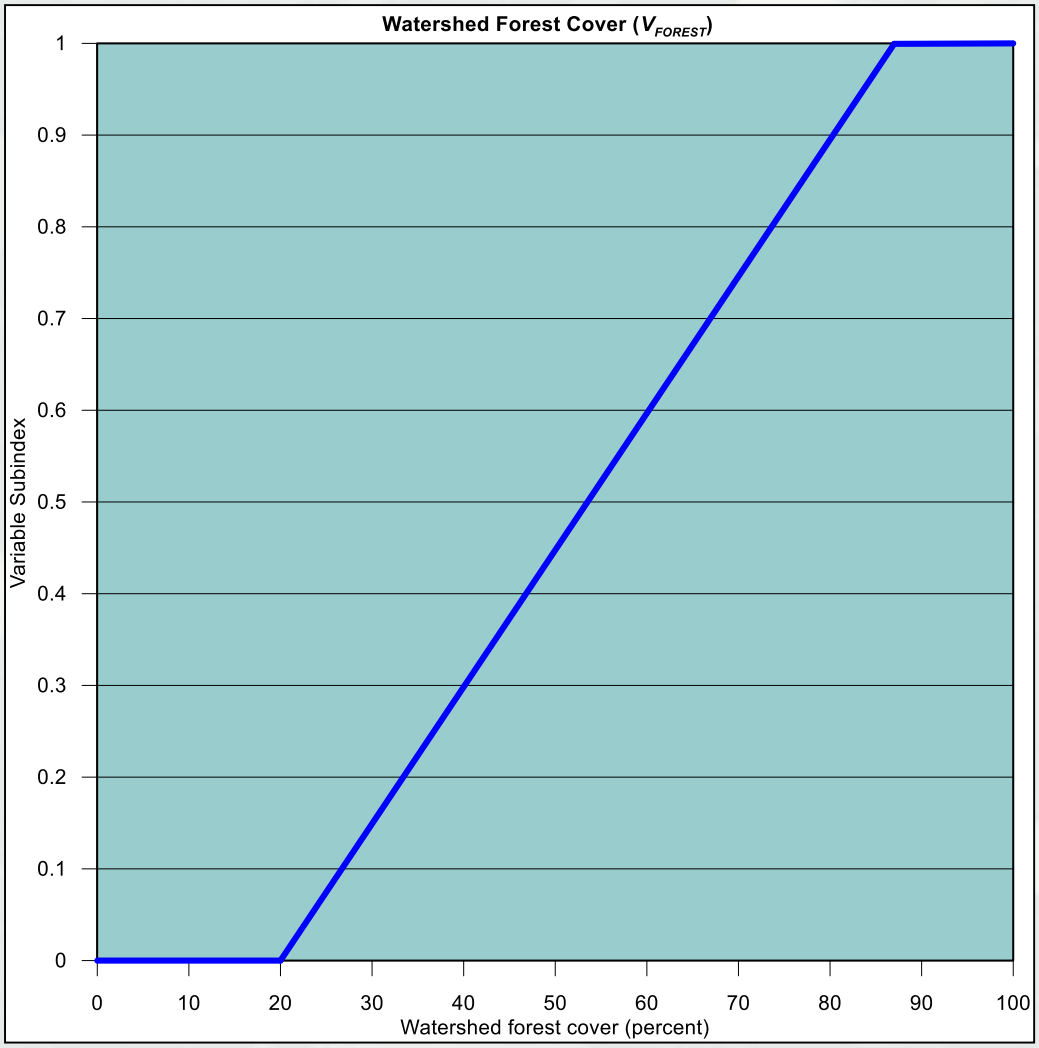
(V_{FOREST})

- Percent forested land cover in the watershed of the stream assessment area
- Stream reaches with ≥93% forest receive a score of 1.0
- Used in the hydrology, biogeochemistry and habitat functions for perennial streams

How to Measure Percent Forest

- Delineate watershed up-slope of the stream assessment reach using topographic maps, aerial photos, or other methods
- Estimate percent forest cover using remote techniques, verify in the field

Percent Forest Variable Scaling



Questions?